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Octagonal Fuzzy Transportation Problem Using Different Ranking Method

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ABSTRACT
Transportation Problem is used on supply and demand of commodities transported from one source to the different destinations. Finding solution of Transportation Problems are North-West Corner Rule, Least Cost Method and Vogel's Approximation Method etc. In this paper Octagonal Fuzzy Numbers using Transportation problem by Best Candidates Method and Robust ranking method and Centroid Ranking Technique and Proposed Ranking Method. A Comparative study is Triangular Fuzzy Numbers and Trapezoidal Fuzzy Numbers and Octagonal Fuzzy Numbers. The transportation cost can be minimized by using of Proposed Ranking Method under Best Candidates Method. The procedure is illustrated with a numerical example.

KEYWORDS: *Transportation problems, Octagonal fuzzy numbers, Robust Ranking method, BCM method, CRT, PRM, Initial Basic Feasible Solution, Optimal Solution*

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1. INTRODUCTION

The central concept in the problem is to find the least total transportation cost of commodity in different method. In general, transportation problems are solved with assumptions that the supply and demand are specified in precise manner. Intuitionistic fuzzy set is a powerful tool to deal with such vagueness.

The concept of Fuzzy Sets, proposed by H. A. Taha, Operations Research- Introduction [8], has been found to be highly useful to deal with vagueness. Many authors discussed the solutions of Fuzzy Transportation Problem (FTP) using various techniques.In 2016, Mrs. Kasthuri. B introduced Pentagonal fuzzy. S. Chanas, W. Kolodziejczyk and A. Machaj, "A fuzzy Approach to the Transportation Problem [3], A New Algorithm for Finding a Fuzzy Optimal Solution. K. Prasanna Devi, M. Devi Durga and G.Gokila, Juno Saju [6] introduced Octagonal Fuzzy Number.

A new method is proposed for finding an optimal solution for fuzzy transportation problem, in which the cost , supplies and Demands are octagonal fuzzy numbers. Using Octagonal fuzzy transportation problem BCM method we get best minimum value of optimal solution.

The paper is organized as follows, in section 2, introduction with some basic concepts of Fuzzy definition , In section 3 introduced Octagonal Fuzzy Definition and proposed algorithm followed by a Numerical example using BCM method and finally the paper is concluded in section 4.

2. PRELIMINARIES

2.1. Definition (Fuzzy set[FS])[3]

Let X be a nonempty set. A fuzzy set $\bar{A}$ of Xis defined as$\bar{A}$={$< x, \mu_{\bar{A}}(\mathrm{x}) > / x \in X$}. Where $\mu_{\bar{A}}(\mathrm{x})$ is called membership function, which maps each element of X to a value between 0 and 1.

2.2. Definition (Fuzzy Number[FN]) [3]

A fuzzy number is a generalization of a regular real number and which does not refer to a single value but rather to a connected a set of possible values, where each possible value has its weight between 0 and 1. The weight is called the membership function.

A fuzzy number $\bar{A}$ is a convex normalized fuzzy set on the real line R such that

There exists at least one x ∈R with $\mu_{\bar{A}}(\mathrm{x}) = 1$.
$\mu_{\bar{A}}(\mathrm{x})\mu_{\bar{A}}(\mathrm{x})$ is piecewise continuous.

2.3. Definition (Triangular Fuzzy Number [TFN])

A Triangular fuzzy number $\bar{A}$ is denoted by 3 – tuples (a_1, a_2, a_3), where a_1, a_2 and a_3 are real numbers and $a_1 \le a_2 \le a_3$ with membership function defined as

$$\mu_{\bar{A}}(x) = \begin{cases} \frac{x - a_1}{a_2 - a_1} \text{ for } a_1 \le x \le a_2 \\ \frac{a_3 - x}{a_3 - a_2} \text{ for } a_2 \le x \le a_3 \\ 0 \text{ otherwise} \end{cases}$$

2.4. Definition (Trapezoidal Fuzzy Number [TrFN])

A trapezoidal Fuzzy number is denoted by 4 tuples $\bar{A} = (a_1, a_2, a_3, a_4)$, Where a_1, a_2, a_3 and a_4 are real numbers and $a_1 \le a_2 \le a_3 \le a_4$ with membership function defined as

$$\mu_{\bar{A}}(x) = \begin{cases} \frac{x - a_1}{a_2 - a_1} \text{ for } a_1 \le x \le a_2 \\ 1 \text{ for } a_2 \le x \le a_3 \\ \frac{a_4 - x}{a_4 - a_3} \text{ for } a_3 \le x \le a_4 \\ 0 \text{ otherwise} \end{cases}$$

2.5. Definition (Octagonal Fuzzy Number [OFN])

A Fuzzy Number $\bar{A}_{OC}$ is a normal Octagonal Fuzzy Number denoted by

$\bar{A} = (a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8)$.

Where $a_1, a_2, a_3, a_4, a_5, a_6, a_7$ and a_8 are real numbers and its membership function $\mu_{\bar{A}}(x)$ is given below,

$$\mu_{\bar{A}}(x) = \begin{cases} 0 \text{ for } x < a_1 \\ k\left(\frac{x - a_1}{a_2 - a_1}\right) \text{ for } a_1 \le x \le a_2 \\ k \text{ for } a_2 \le x \le a_3 \\ k + (1-k)\left(\frac{x - a_3}{a_4 - a_3}\right) \text{ for } a_3 \le x \le a_4 \\ 1 \text{ for } a_4 \le x \le a_5 \\ k + (1-k)\left(\frac{a_6 - x}{a_6 - a_5}\right) \text{ for } a_5 \le x \le a_6 \\ k \text{ for } a_6 \le x \le a_7 \\ k\left(\frac{a_8 - x}{a_8 - a_7}\right) \text{ for } a_7 \le x \le a_8 \\ 0 \text{ for } x > a_8 \end{cases}$$

3.1. BEST CANDIDATES METHOD (BCM) :[2]

Step1:

Prepare the BCM matrix, If the matrix unbalanced, then the matrix will be balanced without using the added row or column candidates in solution procedure.

Step2:

Select the best candidate that is for minimizing problems to the minimum cost, and maximizing profit to the maximum cost. Therefore, this step can be done by electing the best two candidates in each row. If the candidate repeated more than two times, then the candidate should be elected again. As well as, the columns must be checked such that if it is not have candidates so that the candidates will be elected for them. However, if the candidate is repeated more than one time, the elect it again.

Step3:

Find the combinations by determining one candidate for each row and column, this should be done by starting from the row that have the least candidates, and then delete that row and column. If there are situations that have no candidate for some rows or columns, then directly elect the best available candidate. Repeat Step 2 by determining the next candidate in the row that started from. Compute and compare the summation of candidates for each combination. This is to determine the best combination that gives the optimal solution.

3.2. ROBUST RANKING TECHNIQUES:[11]

Robust ranking technique which satisfy compensation, linearity, and additively properties and provides results which are consist human intuition. If ã is a fuzzy number then the Robust Ranking is defined by,

R(ã) = $\int_0^1 (0.5)\,(a_\alpha^L,\ a_\alpha^U)\, d\alpha$.

Where $(a_\alpha^L,\ a_\alpha^U)$ is the α level cut of the fuzzy number ã.

$[a_\alpha^L,\ a_\alpha^U] = \{[(b\text{-}a)\,\alpha + a], [d - (d-c)\alpha], [(f-e)\alpha + e], [h - (h-g)\alpha]\}$

In this paper we use this method for ranking the objective values. The Robust ranking index R(ã) gives the representative value of fuzzy number ã.

3.3. RANKING OF GENERALIZED OCTAGONAL FUZZY NUMBERS:[12]

Ranking of fuzzy numbers are very important task to reduce the more numbers. Nowadays number of proposed ranking techniques is available. Ranking methods map fuzzy number directly into the real line i.e. which associate every fuzzy number with a real number.

The centroid point of an octagon is considered to be the balancing point of the trapezoid. Divide the octagon into three plane figures. These three plane figures are a trapezium ABCR, a hexagon RCDEFS, and again a trapezium SFGH respectively. Let the centroid of three plane figures be G_1, G_2 and G_3 respectively.

The centroid of these centroids G_1, G_2 and G_3 is taken as a point of reference to define the ranking of generalized octagon fuzzy numbers. The reason for selecting this point as a point of reference is that each centroid point G_1 of a trapezoid ABCR, G_2 of a hexagon RCDEFS and G_3 of a trapezoid SFGH are balancing point of each individual plane figure and the centroid o these centroids points is much more balancing point for a general octagonal fuzzy number.

Consider a generalized octagonal fuzzy number $A_o = (a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8; w)$. The centroid of these plane figures is

$G_1 = \left(\frac{a_1+2a_2}{3} + \frac{a_2+a_3}{2} + \frac{2a_3+a_4}{3} + \frac{w}{6} + \frac{w}{4} + \frac{w}{6}\right)$

$G_1 = \left(\frac{2a_1+7a_2+7a_3+2a_4}{18}, \frac{7w}{36}\right)$

Similarly,

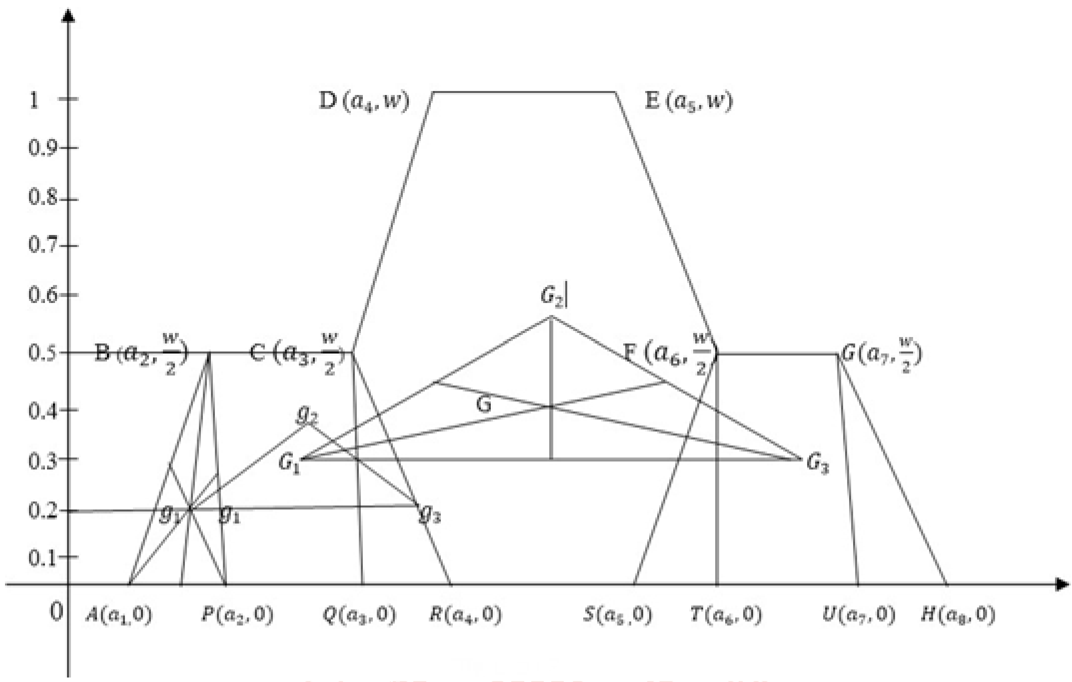
$G_3 = \left(\frac{2a_5+7a_6+7a_7+2a_8}{18}, \frac{7w}{36}\right)$

$G_2 = \left(\frac{a_1+2a_4+2a_5+a_6}{6}, \frac{w}{2}\right)$

The equation of the line G_1, G_3 is $y = \frac{w}{2}$, and does not lie on the line G_1 and G_3. Thus G_1, G_2 and G_3 are non-collinear and they form a triangle.

The ranking function of the generalized hexagonal fuzzy number $A_o = (a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8; w)$ which maps the set of all fuzzy numbers to a set of real numbers is defined as

$$R(A_o) = G_A(x_0, y_0) = \left(\frac{2a_1+7a_2+10a_3+8a_4+8a_5+10a_6+7a_7+2a_8}{54}, \frac{8w}{27}\right)$$



3.4. PROPOSED RANKING METHOD:
The ranking function of Octagonal Fuzzy Number (OIFN) $A_o = (a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8)$ maps the set of all Fuzzy numbers to a set of real numbers defined as

$$R(A_o) = \left(\frac{2a_1 + 3a_2 + 4a_3 + 5a_4 + 5a_5 + 4a_6 + 3a_7 + 2a_8}{28}, \frac{7w}{28}\right)$$

3.5. COMPARISON ROBUST RANKING, CRT AND PRM METHODS:[1]
Solutions of Fuzzy Transportation Problem Using Best Candidates Method and Different Ranking Techniques [1], The transportation costs per pump on different routes, rounded to the closest dollar using Triangular Fuzzy Numbers and Trapezoidal Fuzzy Numbers are given below. Now this results are compared with the results for Octagonal Fuzzy Numbers.

COMPARISON OF ROBUST RANKING AND CRT:[1]

S.NO	Fuzzy Numbers	Methods	Robust Ranking	CRT Technique
1	Triangular Fuzzy Numbers	BCM	59,905	10,936.33
		VAM	61,010	10,962.23
		NWCR	65,275	12,010.61
		LCM	66,515	12,211.77
2	Trapezoidal Fuzzy Numbers	BCM	59,850	9,049.66
		VAM	59,950	10,156.5
		NWCR	65,315	10,072.43
		LCM	65,210	9,690.87

3.6. Numerical Example:

	BANGALORE	PUNE	NEWDELHI	KOLKATA	SUPPLY
KOREA	(71,72,73,74, 75, 76,77,78)	(66,67,68,69, 70,71,72,74)	(80,81,82,83, 84,85,86,88)	(78,79,80,81, 82,83,84,85)	(86,87,88,89, 90,91,92,94)
JAPAN	(82,83,84,85, 86,87,88,90)	(76,78,80,82, 83,84,85,86)	(92,93,94,95, 96,97,98,100)	(84,85,86,87, 88,89,90,92	(130,135,140,145, 150,155,160,170)
UK	(98,99,100,101, 102,103,104,106)	(86,87,88,89, 90,91,92,94)	(132,133,134,135, 136,137,138,140)	(114,115,116,118, 120,122,124,126)	(210,215,220,225, 230,235,240,250)
LUPTON	(96,97,98,99, 100,101,102,103)	(92,93,94,95, 96,97,98,100)	(110,112,113,114, 115,116,118,120)	(100,102,104,106, 108,112,116,118	(140,145,150,160, 170,180,190,200)
DEMAND	(90,92,94,96, 98,100,105,110)	(180,190,195,200, 205,210,215,220)	(160,165,170,175, 180,185,190,195)	(120,130,140,150, 160,170,180,190)	

ΣDemand = Σ Supply

Using the Robust Ranking Technique the above problem can be reduced as follows:

	BANGALORE	PUNE	NEW DELHI	KOLKATA	SUPPLY
KOREA	74.5	69.5	83.5	81.5	89.5
JAPAN	85.5	81.5	95.5	87.5	148
UK	101.5	89.5	135.5	119	228
LUPTON	99.5	95.5	114.5	108	166.5
DEMAND	98	201.5	177.5	155	

Applying **VAM** method, Table corresponding to initial basic feasible solution is = 59042.75
Applying **North West Corner method**, Table corresponding to initial basic feasible solution is = 64862.5
Applying **LCM** method, Table corresponding to initial basic feasible solution is = 65942
Applying **BCM** method, Table corresponding to Optimal solution is = 63223

Using the Centroid Ranking Method the above problem can be reduced as follows:

	BANGALORE	PUNE	NEW DELHI	KOLKATA	SUPPLY
KOREA	21.6	20.1	23.8	23.6	25.9
JAPAN	24.8	23.7	27.7	25.3	42.8
UK	29.4	25.9	33.2	46.3	66.0
LUPTON	43.5	27.7	33.2	31.3	55.2
DEMAND	28.3	58.7	51.4	44.9	

Σ Demand $\neq$ Σ Supply

	BANGALORE	PUNE	NEW DELHI	KOLKATA	DUMMY	SUPPLY
KOREA	21.6	20.1	23.8	23.6	0	25.9
JAPAN	24.8	23.7	27.7	25.3	0	42.8
UK	29.4	25.9	33.2	46.3	0	66.0
LUPTON	43.5	27.7	33.2	31.3	0	55.2
DEMAND	28.3	58.7	51.4	44.9	6.61	

Σ Demand = Σ Supply

Applying **VAM** method, Table corresponding to initial basic feasible solution is = 4027.18
Applying **North West Corner method**, Table corresponding to initial basic feasible solution is = 5162.26
Applying **LCM** method, Table corresponding to initial basic feasible solution is = 5249.66
Applying **BCM** method, Table corresponding to Optimal solution is = 5249.99

Using Proposed Ranking Method the above problem can be reduced as follows:

	BANGALORE	PUNE	NEW DELHI	KOLKATA	SUPPLY
KOREA	18.6	17.4	20.9	20.4	22.3
JAPAN	21.4	20.5	23.9	23.5	36.9
UK	25.4	22.4	33.9	29.8	56.9
LUPTON	24.9	23.9	28.6	27	41.5
DEMAND	24.4	50.5	44.3	38.6	

Σ Demand $\neq$ Σ Supply

	BANGALORE	PUNE	NEW DELHI	KOLKATA	SUPPLY
KOREA	18.6	17.4	20.9	20.4	22.3
JAPAN	21.4	20.5	23.9	23.5	36.9
UK	25.4	22.4	33.9	29.8	56.9
LUPTON	24.9	23.9	28.6	27	41.5
DUMMY	0	0	0	0	0.3
DEMAND	24.4	50.5	44.3	38.6	

Σ Demand = Σ Supply

Applying **VAM** method, Table corresponding to initial basic feasible solution is

	BANGALORE	PUNE	NEW DELHI	KOLKATA	SUPPLY
KOREA	18.6	17.4 [22.3]	20.9	20.4	22.3
JAPAN	21.4	20.5	23.9 [36.9]	23.5	36.9
UK	25.4 [24.4]	22.4 [28.2]	33.9	29.8 [4.3]	56.9
LUPTON	24.9	23.9	28.6 [7.1]	27 [34.4]	41.5
DUMMY	0	0	0 [0.3]	0	0.3
DEMAND	24.4	50.5	44.3	38.7	

Minimum Cost = $22.3\times 17.4 + 36.9 \times 25.3 + 24.4 \times 25.4 + 28.2 \times 22.4 + 29.8 \times 4.3 + 7.1 \times 28.6 + 34.4 \times 27 + 0 \times 0.3$
= 3781.37

Applying **North West Corner** method, Table corresponding to initial basic feasible solution is

	BANGALORE	PUNE	NEWDELHI	KOLKATA	SUPPLY
KOREA	18.6 [22.3]	17.4	20.9	20.4	22.3
JAPAN	21.4 [2.1]	20.5 [34.8]	23.9	23.5	36.9
UK	25.4	22.4 [15.7]	33.9 [41.2]	29.8	56.9
LUPTON	24.9	23.9	28.6 [3.1]	27 [38.4]	41.5
DUMMY	0	0	0	0 [0.3]	0.3
DEMAND	24.4	50.5	44.3	38.6	

Minimum Cost = $22.3\times 18.6 + 2.1 \times 21.4 + 34.8 \times 20.5 + 15.7 \times 22.4 + 41.2 \times 33.9 + 3.1 \times 28.6 + 38.4 \times 27 + 0 \times 0.3$
= 4046.94

Applying **LCM** method, Table corresponding to initial basic feasible solution is

	BANGALORE	PUNE	NEWDELHI	KOLKATA	SUPPLY
KOREA	18.6	17.4 [22.3]	20.9	20.4	22.3
JAPAN	21.4 [8.7]	20.5 [28.2]	23.9	23.5	36.9
UK	25.4	22.4	33.9 [44.3]	29.8 [12.6]	56.9
LUPTON	24.9 [15.4]	23.9	28.6	27 [26.1]	41.5
DUMMY	0 [0.3]	0	0	0	0.3
DEMAND	24.4	50.5	44.3	38.6	

Minimum Cost = $22.3\times 17.4 + 8.7 \times 21.4 + 28.2 \times 20.5 + 44.3 \times 33.9 + 12.6 \times 29.8 + 15.4 \times 24.9 + 26.1 \times 27 + 0 \times 0.3$
= 4117.71

Applying **BCM** method, Table corresponding to Optimal solution is

	BANGALORE	PUNE	NEWDELHI	KOLKATA	SUPPLY
KOREA	18.6	17.4 [22.3]	20.9	20.4	22.3
JAPAN	21.4 [24.4]	20.5 [12.5]	23.9	23.5	36.9
UK	25.4	22.4 [15.7]	33.9 [2.5]	29.8 [38.7]	56.9
LUPTON	24.9 [15.4]	23.9	28.6 [41.5]	27	41.5
DUMMY	0 [0.3]	0	0 [0.3]	0	0.3
DEMAND	24.4	50.5	44.3	38.6	

S.NO	Ranking Methods	Methods	Triangular Fuzzy Numbers	Trapezoidal Fuzzy Numbers	Octagonal Fuzzy Numbers
1	Robust Ranking	BCM	59,905	59,850	59,790
		VAM	61,010	59,950	59,042.75
		NWCR	65,275	65,315	64,862.5
		LCM	66,515	65,210	64,942
2	CRT Technique	BCM	10,936.33	9,049.66	5,249.99
		VAM	10,962.23	10,156.5	4,027.18
		NWCR	12,010.61	10,072.43	5,162.26
		LCM	12,211.77	9,690.87	5,249.66
3	Proposed Ranking Method	BCM			3,938.74
		VAM			3,781.37
		NWCR			4,046.94
		LCM			4,117.71

Minimum Cost = $22.3\times 17.4 + 24.4 \times 21.4 + 12.5 \times 20.5 + 15.7 \times 22.4 + 33.9 \times 2.5 + 29.8 \times 38.7 + 41.5 \times 28.6 + 0 \times 0.3$
= 3938.74

4. CONCLUSION:

In this paper, We took the example of Fuzzy Transportation Problem Using Best Candidates Method , where the result arrived at using Octagonal Fuzzy Numbers are more cost effective then Best Candidate Method .we discussed finding Initial Basic solution and Optimal Solution for Octagonal Fuzzy Transportation. The transportation cost can be minimized by using of Proposed Ranking Method under Best Candidates Method. It is concluded that Octagonal Fuzzy Transportation method proves to be minimum cost of Transportation.

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